ULTRASONIC MOTOR AND ELECTRONIC APPLIANCE WITH ULTRASONIC MOTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to ultrasonic motors used for timepieces, cameras, printers, memory devices and so on and, more particularly, to a ultrasonic motor which is reduced in vibration leak to efficiently transmit a drive force to a moving member but made in small in size with improved reliability.

2. Description of the Related Art

The ultrasonic motor utilizes, as power to move a moving member, elliptic vibration that is a resultant vibration of expansion-and-contraction vibration and flex vibration caused on a piezoelectric element applied by a drive signal such as an alternating current voltage. Recently, attentions have being drawn to the ultrasonic motors particularly in the field of micro-mechanics, because of their high electric-to-mechanical energy conversion efficiency.

The ultrasonic motor generally has a piezoelectric element as a drive power source, a signal transmission means for transmitting drive signals to the piezoelectric element, and an elastic member for pressure-contacting the piezoelectric element with the moving member to efficiently transmit drive power to the moving member.

Where such a ultrasonic motor is installed on a circuit board such as a printed circuit board, it is held on the circuit board by using a support member to hold one part of a vibrator having a piezoelectric element for the ultrasonic motor.

However, there has been a necessity for the conventional ultrasonic motor to provide the piezoelectric element with a signal transmission part, such as conductor wires, to apply drive signal to the piezoelectric element. That is, there encountered leakage of the expansion-and-contraction vibration and flex vibration caused on the piezoelectric element to an outside through both the support member and the signal transmission part. The leakage of expansion-and-contraction vibration and flex vibration was also through the elastic member to the outside.

As a result, the conventional ultrasonic motor could not efficiently transmit drive force to the moving member, and impaired in ultrasonic motor characteristic of high electric-to-mechanical energy conversion efficacy.

Meanwhile, mounting a plurality of elements on the piezoelectric element prevented against size reduction for the ultrasonic motor and hence increased factors to lower its reliability.

Accordingly, it is an object of the present invention to provide a ultrasonic motor which is decreased in factors to leak drive force produced on a piezoelectric element and efficiently

transmit the drive force to a moving member, wherein size reduction and improvement in reliability are achieved.

SUMMARY OF THE INVENTION

That is, the means to solve the problem is characterized by a ultrasonic motor, as claimed, comprises: a piezoelectric vibrator for oscillating due to an input drive signal and generating a drive force; and a support member for supporting the piezoelectric vibrator on a substrate; wherein the support member has a signal transmission function to transmit the drive signal to the piezoelectric vibrator.

Here, the support member is formed, for example, of a resin having on a surface a signal line or of a metal to have a signal transmission function.

Meanwhile, the piezoelectric vibrator is formed, for example, only by a piezoelectric element. Alternatively, a metal vibrator bonded to a piezoelectric element may be applied thereto. The drive control may be either of a self-oscillation type or a separately-oscillation type.

According to this invention, because the drive signal is transmitted through the support member to the piezoelectric vibrator, there is no need to separately providing a signal transmission part.

Accordingly, the expansion-and-contraction vibration and flex vibration caused on the piezoelectric vibrator is reduced in leak amount to an outside as compared to the conventional.

Therefore, the ultrasonic motor according to the invention efficiently transmit a drive force caused on the piezoelectric vibrator to the moving member.

Also, the unnecessity of separately providing a signal transmission part offers size reduction for the ultrasonic motor and hence decrease in the number of manufacture processes resulting in reduction in manufacture cost.

Next, the present invention is characterized in that, in the aforesaid ultrasonic motor, the support member has elasticity, and the piezoelectric vibrator being press-contacted with a moving member by an elastic force of the support member.

The method to provide the support member with elasticity includes using as a material, for example, a conductive rubber or the like.

According to this invention, a function is available equivalent to that of the above invention. In addition, the piezoelectric vibrator is urged on the moving member by the elasticity of the support member. Accordingly, the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

Next, the present invention is characterized in that, in the aforesaid ultrasonic motor, the support member has a constriction that is made thin than a portion connected to the piezoelectric vibrator.

According to this invention, the provision of the constriction in the support member reduces the vibration transmission area in the support member so that the constriction reduces the leak of vibration furthermore. Consequently, the ultrasonic motor transmits a drive force to the moving member with higher efficiency. Furthermore, the support member deforms due to the constriction, and has an operation equivalent to that of the above invention.

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the support member is a part of the substrate.

Acceding to this invention, because the support member is one part of the substrate, the ultrasonic motor is easy to mount on the substrate.

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the piezoelectric vibrator is provided in a recess formed in the substrate.

Here, the piezoelectric vibrator is mounted such that the surface of the substrate and the surface of the piezoelectric vibrator are positioned in a same plane, through the support member as one part of the substrate which has been left without made in recess when forming a recess in the substrate.

According to this invention, a similar operation is available to that of the above invention. In addition, there is decrease in thickness of the ultrasonic motor plus the

substrate. Accordingly the application of the ultrasonic motor is broadened as compared to the conventional ultrasonic motor.

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the piezoelectric vibrator is mounted on the support member.

According to this invention, a similar operation is available to that of the above invention. In addition, because the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a similar procedure to conventional mounting of transistors or capacitors on a substrate. That is, in the ultrasonic motor of the present invention, it is possible to simultaneously mount a motor and circuits on a substrate by using an existing electric circuit production line. Accordingly, the ultrasonic motor is reduced in mounting cost and stabilized in mounting process. Consequenty, the ultrasonic motor is reduced in variation of performance with improved reliability.

Further, the present invention is characterized in that, in the aforesaid ultrasonic motor, the support member is provided with at least one part of a drive circuit.

According to this invention, because the support member is provided with at least part of a drive circuit, the drive circuit elements required to be mounted on a substrate are decreased, thereby reducing the size of the ultrasonic motor. Also, there is reduction of variation in ultrasonic motor

performance resulting from connection between the piezoelectric vibrator and the drive circuit. Further, circuit parts can be mounted and adjusted so as to adjust the variation in the motor and circuits, thus improving the reliability.

Further, the preset invention is characterized in that, in the aforesaid ultrasonic motor, the support member supports the piezoelectric vibrator at a point corresponding to a node of vibration caused thereon.

Here, the vibration includes, for example, flex vibration and expansion-and-contraction vibration.

According to this invention, the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration. Because there is no displacement in the node of vibration, there is further decrease in externally leaking amount of vibration caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the ultrasonic motor is an electronic appliance having the aforesaid ultrasonic motor.

According to this invention, because the aforesaid ultrasonic motor is used in which less vibration leaks to an outside as compared to the conventional ultrasonic motor, the

ultrasonic motor is increased in output. That is, because the ultrasonic motor and its drive circuit are reduced in size, the electronic appliance with ultrasonic motor is decreased in size.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing a structure of a ultrasonic motor 1 according to a first embodiment of the present invention;

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Figs 2a - 2f are views ~~Fig. 2 is a view~~ showing a structure of a piezoelectric vibrator 14 and piezoelectric vibrator 15 with electrodes 13a to 13f used in a piezoelectric element 10 for the ultrasonic motor 1;

Fig. 3 is a schematic view showing operation of the ultrasonic motor 1;

Fig. 4 is a view showing structural essential elements of a ultrasonic motor 2 as a modification to the ultrasonic motor 1;

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Figs 5a and 5b are views ~~Fig. 5 is a view~~ showing a structure of a ultrasonic motor 3 according to a second embodiment of the present invention;

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Figs 6a and 6b are views ~~Fig. 6 is a view~~ showing structural essential elements of a ultrasonic motor 4 as a modification to the ultrasonic motor 3;

Fig. 7 is a view showing a structure of an electronic appliance with ultrasonic motor 5 according to a third embodiment of the present invention;

DETAILED DESCRIPTION OF THE INVENTION

Embodiments will be explained in detail to which the invention is applied, with reference to Fig. 1 to Fig. 7.

Fig. 1 to Fig. 3 are figures for explaining a ultrasonic motor 1 as a first embodiment of the invention, while Fig. 4 is a figure showing a structure of a ultrasonic motor 2 as a modification of the ultrasonic motor 1.

Meanwhile, Fig. 5 is a figure for explaining a ultrasonic motor 3 as a second embodiment of the invention, while Fig. 6 is a figure for explaining a ultrasonic motor 4 as a modification of the ultrasonic motor 3.

Meanwhile, Fig. 7 is a figure for explaining an electronic appliance 5 with a ultrasonic motor as a third embodiment of the invention.

[EMBODIMENTS]

[First Embodiment]

Fig. 1 is a view showing an overall structure of a ultrasonic motor 1.

As shown in Fig. 1 the ultrasonic motor 1 is structured by a piezoelectric element 10 (piezoelectric vibrator) that is inputted by drive signal X, such as a sine wave, to elliptical vibrate, support members 11, 11 that hold the piezoelectric elements 10 on a substrate 7 and deliver signals through signal lines 7a, 7b on the substrate 7, a symmetry member 12 having a moving member 12a contacted with an end face of the piezoelectric element 10, and a drive IC 6 provided on the

substrate 7 to input drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and the support members 11, 11. Incidentally, the drive IC 6 outputs drive signal X to a predetermined portion of an electrode of the piezoelectric element 10, hereinafter referred to, according to a forward drive command, backward drive command and stop command to be externally inputted through signal lines 7c, 7d and 7e.

That is, the ultrasonic motor 1 is a ultrasonic motor which causes elliptic vibration at the piezoelectric member 10 end face according to drive signal X given from the drive IC 6 thereby moving the moving member 12a in directions parallel to the end face.

First, the support members 11 are explained in detail.

The support members 11 are formed of a resin, for example, generally in a L-form and each having, for example, three signal lines on a surface. That is, the support members 11, 11 have, for example, totally 6 signal lines which number is same as the number of electrodes provided on the side faces of the piezoelectric element 10.

The support member 11 has one side 11a fixed on the signal line 7a of the substrate 7, for example, through solder. Also, the support member 11 has the other side 11b fixed on a side face of the piezoelectric element 10, for example, through conductive adhesive in a manner holding a node of flexional vibration.

Meanwhile, the signal line 7a, 7b are a bundle of three signal lines. This number of signal lines is the same as the number of electrodes provided on the piezoelectric element 10 one side face, hereinafter referred to, which signal lines are separately connected respectively to signal lines of the support member 11.

Due to this, the support member 11 supports the piezoelectric element 10 on the substrate 7 and connects between the electrodes of the piezoelectric element 10 and the signal line 7a or signal line 7b.

In this manner, the support member 11 formed with the signal line also serves as a signal transmission means to transmit a signal to the piezoelectric element 10. That is, the number of parts connected to the piezoelectric member 10 is reduced and hence the ultrasonic motor 1 is made smaller in size.

Next, the piezoelectric element 10 will be explained in detail.

The piezoelectric element 10 has a piezoelectric vibrator 14 as a flex vibration source laminated thereon with a piezoelectric vibrator 15 as an expansion-and-contraction vibration source in one body, and is structured having an electrode 13a, electrode 13b, electrode 13c, electrode 13d, electrode 13e and electrode 13f.

These electrode 13a to 13f are respectively connected to the 6 signal lines provided on the support members 11, 11, and voltages are to be individually applied thereto.

Incidentally, a projection may be formed in the piezoelectric element 10 at generally center to contact with and drive the moving member 12a.

Here, the piezoelectric vibrator 14, 15 and the electrodes 13a to 13f will be explained in detail, with reference to Fig. 2.

Fig. 2(a) is a view showing an arrangement of electrodes in one face of the piezoelectric element 10. Meanwhile, Fig 2(e) is a view showing an arranging position of electrodes in side face 10a (see (a) of the figure), while (f) of the figure is a view showing an arranging position of electrodes in side face 10b (see (a) of the figure).

Meanwhile, Fig. 2(b) is a view showing one surface of the piezoelectric vibrator 14, while (d) of the figure shows the other surface of the piezoelectric vibrator 15. Meanwhile, Fig. 2(c) is a top view of the piezoelectric vibrator 15.

First explained is a polarization structure in each piezoelectric vibrator.

The piezoelectric vibrator 14 is structured, as shown in Fig. 2(b), of divided into two in a vertical direction and also two in a horizontal direction into four, i.e. a polarization region 14a, a polarization region 14b, a polarization region

14c and a polarization region 14d that are to be polarized + at their top surfaces in a laminated direction.

Meanwhile, the piezoelectric vibrator 15 is structured, as shown in Fig. 2(d), having one polarization region almost in an entire surface so that it can be polarized + ,for example, in an underside in the lamination direction.

Next explained are structures of the electrodes 13a to 13f.

The electrode 13a almost covers over a top surface of the polarization region 14a of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14a, 14a ... of a plurality of piezoelectric vibrators 14, 14 ..., at the top surfaces, are to become a same potential by the electrode 13a continuing through extended portions to the side face 10b.

Similarly, the electrode 13b almost covers over one surface of the polarization region 14b of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14b, 14b ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, are to become a same potential by the electrode 13b continuing through extended portions to the side face 10b.

Meanwhile, the electrode 13c almost covers over one surface of the polarization region 14c of the piezoelectric vibrator 14, one part of which is extended to a side face 10b.

That is, all the polarization regions 14c, 14c ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, are to become a same potential by the electrode 13c continuing through extended portions to the side face 10a.

Similarly, the electrode 13d almost covers over one surface of the polarization region 14d of the piezoelectric element 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14d, 14d ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, are to become a same potential by the electrode 13d continuing through extended portions to the side face 10a.

Also, the electrode 13e almost covers over the other surface of the polarization region 15a of the piezoelectric vibrator 15, one part of which is extended to a side face 10a. That is, all the polarization regions 15a, 15a ... of a plurality of piezoelectric vibrators 15, 15 ..., at the other surfaces, are to become a same potential by the electrode 13e continuing through extended portions to the side face 10a.

Further, the electrode 13f is sandwiched between the other surface of the piezoelectric vibrator 14 and the one surface of the piezoelectric vibrator 15. Consequently, the electrode 13f covers over all the undersides of the four polarization regions 14a, 14b, 14c and 14d of the piezoelectric vibrator 14, and at the same time over the entire top surface of the polarization region 15a of the piezoelectric vibrator 15, and

part of which is extended to the side face 10b. That is, all the polarization regions 14d, 14d ... of the plurality of piezoelectric vibrators 14, 14, at the top surfaces, are to become a same potential by the electrode 13f continuing through the extended portions to the side face 10b.

Incidentally, the number of the piezoelectric vibrators 14, 15 may be increased appropriately. In this case, the electrode structure is changed depending on a lamination method.

Now, the operation of the ultrasonic motor 1 is explained using Fig. 3.

If the drive IC 6 is externally inputted by a drive command signal in a positive direction through the signal line 7c shown in Fig. 1, it outputs a drive signal X to the electrodes 13a, 13d, 13e and 13f of the piezoelectric element 10 through the signal lines 7a, 7b and the aforesaid signal lines on the support member 11.

Thereupon, in the piezoelectric vibrator 15 the drive signal X is inputted to the electrode 13e with respect to the electrode 13f as a reference electrode. Accordingly, the polarization region 15a expands or contracts. Consequenty, the piezoelectric vibrator 15 expands or contracts in a lengthwise direction as shown by a rectangular 15' in Fig. 3.

Simultaneously, in the piezoelectric vibrator 14 the drive signal X is inputted to the electrodes 13a, 13d with

respect to the electrode 13f as a reference electrode. Accordingly, the polarization regions 14a, 14d expands. Consequenty, the piezoelectric vibrator 14 effects flexional vibration as shown by a rectangular 14' in Fig. 3.

At this time, the members connected to the piezoelectric element 10 is only the support members 11, 11. Because no signal transmission means is separately provided, vibration leak is reduced from the piezoelectric element 10.

As a result, the expanding-and-contracting vibration on the piezoelectric vibrator 15 and the flectional vibration on the piezoelectric vibrator 14 are combined so that the piezoelectric element 10 at the end face effects elliptic vibration in a Z direction in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in the Z direction as a positive direction.

Also, if the drive IC 6 is externally inputted by a drive command in a reverse direction through the signal line 7d, it outputs a drive signal X to the electrodes 13b, 13c, 13e and 13f of the piezoelectric element 10 through the signal lines 7a, 7b and the aforesaid signal lines on the support member 11.

Thereupon, because the electrodes 13b, 13c are inputted by the drive signal X, the flex vibration of the piezoelectric vibrator 14 with respect to the expanding-and-contracting vibration as a reference of the piezoelectric vibrator 15 is reversed in direction from the positive direction case as

stated above. Accordingly, the piezoelectric element 10 at the end face effects elliptic vibration in a direction reverse to Z in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in a reverse direction.

As described above, according to the ultrasonic motor 1 as a first embodiment of the present invention, because the drive signal X is delivered to the piezoelectric element 10 through the signal line 7a by the support member 11, there is no necessity of separately providing a signal transmission part. Accordingly, the expanding-and-contracting vibration and flex vibration cased on the piezoelectric element 10 are reduced in amount of leak to an outside, as compared to the conventional. Also, because the support member 11 are fixed in a manner holding a flex vibration node, the flex vibration caused on the piezoelectric element 10 is further reduced in amount of leak to an outside.

Further, because there is no necessity of separately providing a signal transmission part, the ultrasonic motor 1 is reduced in size and also the number of manufacture processes, reducing manufacturing cost.

Accordingly, the ultrasonic motor 1 effectively transmit a drive force generated on the piezoelectric element 10 to the moving member 12a.

Incidentally, in the embodiment of the present invention, although the support member 11 was made of a resin, the present

invention is not limited to this and may be of a metal, for example. In this case, the support member 11 has to be provided corresponding to the number of electrodes.

Further, the support member 11 may be provided with an entire or one part of an electric circuit, e.g. self-oscillation transmitting circuit. In this case, the number of elements to be provided on the substrate decreases, the substrate area required decreases. Accordingly, the ultrasonic motor 1 is further reduced in size.

Incidentally, the present embodiment may be modified as below.

Fig. 4 is a view showing a structure of elements of a ultrasonic motor 2 of a first modification to the present embodiment.

The ultrasonic motor 2 is made by a structure, in the ultrasonic motor 1, using support members 21 in place of the support members 11.

The support member 21 is formed with a constriction in a generally I-form in the support member 11 with other parts structured similar to those of the support member 11. That is, the support member 21 possesses elasticity. Also, the support members 21 are fixed at side faces of the piezoelectric element 10 so that they can deflect in a direction parallel to the side face of the piezoelectric element 10.

Accordingly, the support members 21 presses the piezoelectric element 10 against the moving member 12a (omittedly shown in Fig. 4).

That is, the ultrasonic motor 2 as an equivalent function to the ultrasonic motor 1. Further, because the piezoelectric element 10 is put in pressure contact with the moving member 12a by the support members 21, there is increase of frictional force acted on between the piezoelectric element 10 and the moving member 12a. Accordingly, the drive force caused on the piezoelectric element 20 is conveyed to the moving member 12a with higher efficiency.

Also, the provision of the constriction decreases a vibration transmission area, further decreasing leak of vibration through the support member 21. Accordingly, the ultrasonic motor 2 transmits a drive force to the moving member 12a with higher efficiency.

Incidentally, the method of providing elasticity to the support member 21 includes a method of forming a support member 21 of a conductive rubber with the shape of the support member 11 used as it is.

Also, the support member 21 may be provided with an entire or part of an electric circuit such as a self-oscillation transmitting circuit.

[Second Embodiment]

Fig. 5 is a view showing a schematic structure of elements of a ultrasonic motor 3.

The ultrasonic motor 3 is made in a structure that the piezoelectric element 30 is mounted on a substrate 8 having a recess by using support members 8b, 8b that are provided as one portions of the substrate 8 in the recess. Also, as shown in Fig 5(b), the piezoelectric member 30 has a top surface almost in a same plane as that of a top surface of the substrate 8. Incidentally, other not-shown structural constituents are almost the same as those of the ultrasonic motor 1.

The support member 8b is structured, as shown in Fig 5(a), to have a support portion for holding the piezoelectric element 30 at a tip end of a terminal extended from the substrate 8. Due to this, the support member 8b is generally in a T-form in section in a parallel direction with the substrate 8. This substrate 8 is formed in a predetermined form, for example, by previously preparing a forming mold for a substrate 8 in a corresponding shape to this. Also, as shown in (b) of the figure, the support portion as a convex portion to support an underside of the piezoelectric element 30. Meanwhile, one support member 8b has at a top face a signal line 8a to be connected to a part of the electrodes of the piezoelectric element 30, while the other support member 8b has at a top face a signal line 8a, 8a to be connected to the remainder of the electrodes of the piezoelectric element 30. Incidentally, the

number of the signal lines 8a or support members 8b or their forming positions may be appropriately changed in accordance with the number of electrodes on the piezoelectric element 30 or a vibrational node position.

Here, the support member 8b is provided so tat it holds a flex vibration node on the piezoelectric element 30, similarly to the support member 11.

The piezoelectric element 30 has almost the same structure as that of the piezoelectric element 10 except for a structure of extending electrodes to end faces 30a, 30b.

Here, when required, a signal line is passed through a hole 8d opened in the substrate 82 so that the signal line is connected to an electrode provided on a backside of the piezoelectric element 30.

That is, if a drive signal X is inputted through signal lines 8a, 8a, 8a to the electrodes of the piezoelectric element 30, the piezoelectric element 30 at the end face effects elliptic vibration to thereby move the moving member (not shown) that is in contact with the end face.

As described above, because in the ultrasonic motor 3 the support members 8b, 8b serves also as a signal transmitting means alike in the ultrasonic motor 1, the expanding-and-contracting vibration and flex vibration occurred on the piezoelectric element 30 is reduced in leak amount to an outside as compare to the conventional. Further, because the support

members 8b are provided in a manner holding a flex vibration node, the flex vibration caused on the piezoelectric element is further reduced in leak amount to the outside.

Accordingly, the ultrasonic motor 3 can efficiently transmit the drive force caused in the piezoelectric element 30 to the moving member.

Also, because the piezoelectric element 30 is provided in the recess of the substrate 8 such that the piezoelectric element 30 and the substrate 8 at their top surfaces are in a same plane, the total thickness of the ultrasonic motor 3 and the substrate 8 are decreased, making the size small. Consequently, the application range of the ultrasonic motor 3 broadens as compared to that of the conventional ultrasonic motor.

Incidentally, the support member 8b may be formed with a constriction in a manner similarly to the support member 21, or the support member 8b only may be formed of conductive rubber. In this case, because the piezoelectric element 30 is pressed against the moving member by the support member 8b, there obtains further increase in the transmission efficiency of drive force to the moving member.

Furthermore, the support member 8b may be provided with an entire or one part of an electric circuit such as a self-oscillation generating circuit. In this case, the number of elements on the substrate decreases to decrease a substrate

area required. Accordingly, the ultrasonic motor 3 is made further smaller.

Incidentally, the present embodiment may be modified as follows.

Fig. 6 is a view showing a schematic structure of essential elements of a ultrasonic motor 4 of a first modification according to the present embodiment. Incidentally, the structural constituents not shown are in almost the same structure as those of the ultrasonic motor 1.

In Fig. 6, the ultrasonic motor 4 is structured such that the piezoelectric element 40 is fixed, corresponding to nodes of flex vibration of the piezoelectric element 40, on surfaces of the support members 8c, 8c ... provided in a recess of a substrate 8 using, for example, solder, as shown in Fig. 6(b).

The support member 8c is structured having a support piezoelectric element 40 support portion provided at a tip of an extension terminal extended from the substrate 8, as shown in Fig. 6(a). The support portion has a top face that is flash with the top face of the substrate 8. Due to this, the sectional form in a parallel direction to the substrate 8 is generally T form.

Also, a predetermined signal line 8a is provided on a surface of the support member 8c corresponding to an electrode of the piezoelectric element 40. Incidentally, the number of signal lines 8a, and the number and position of support members

8c are appropriately changed depending on the number of electrodes of the piezoelectric element 40 or the position of vibration node.

The piezoelectric element 40 is structured generally same as the piezoelectric element 10 except for an electrode extended to an end face.

As described above, in the ultrasonic motor 4 reduced is leak amount to the outside of the expansion-and-contraction and flex vibration caused on the piezoelectric element 40 as compared to the conventional, similarly to the ultrasonic motor 1. Furthermore, because the support member 8c is provided in a manner holding a flex vibration node of the piezoelectric element 40, further reduced is the leak amount to the outside of flex vibration caused in the piezoelectric element 40.

Accordingly, the ultrasonic motor 4 efficiently delivers a drive force produced on the piezoelectric element 40 to the moving member.

Also, the piezoelectric element 40 is mounted through solder on the surfaces of the support members 8c. Accordingly, where for example the circuit board 8 is formed by a printed board, it is possible to mount the piezoelectric element 40 on the circuit board 8 in a similar procedure to conventional mounting of a transistor or capacitor on the board. That is, the ultrasonic motor 4 allows on-board mounting using an

existing electric circuit production line, reducing mounting cost and improving reliability.

Incidentally, the support member 8c may be provided with a constriction similarly to the support member 21 or the support member 8c only may be formed of a conductive rubber. In this case, because the piezoelectric element 40 is pushed against the moving member by the support member 8c, the transmission efficiency of drive force to the moving member further improves.

Also, the support member 8c may be provided with an entire or one part of an electric circuit, such as a self-oscillation circuit.

[Third Embodiment]

Fig. 7 is a block diagram of an electronic appliance with ultrasonic motor 5 that the ultrasonic motor of the present invention is applied to an electronic appliance.

An electronic appliance with ultrasonic motor 5 is realized by providing a piezoelectric element 51 treated by predetermined polarization process, a vibration member 52 joined to an piezoelectric element 51, a moving member 53 to be moved by the vibration member 52, a pressurizing mechanism 54 for applying pressure to the vibration member 52 and moving member 53, a transmission mechanism 55 movable interlinked to the moving member 53, and an output mechanism 56 to be moved based on operation of the transmission mechanism 55.

Incidentally, the pressurizing mechanism 54 is, for example, by the support member 21.

Here, the electronic appliance with ultrasonic motor 5 includes, for example, electronic timepieces, measuring instruments, cameras, printers, printing machines, machine tools, robots, moving apparatuses, memory devices and so on.

Also, the piezoelectric vibrator 51 uses, for example, piezoelectric elements 10, 20, 30. Also, the transmission mechanism 55 uses, for example, a transmission wheel, such as a gear, friction wheel, or the like. The output mechanism 56 uses, for example for a camera, a shutter drive mechanism or lens drive mechanism, and for an electronic timepiece, a pointer drive mechanism or calendar drive mechanism. Where used in a memory device, a head drive mechanism for driving a head to read and write information from and to a memory medium within the information memory device. For a machine tool, a tool feed mechanism or work feed mechanism is used.

Because this electronic appliance with ultrasonic motor 5 uses a ultrasonic motor according to the invention having a higher output as compared to the conventional ultrasonic motor, the ultrasonic motor and its drive circuits are reduced in size. Accordingly, it is smaller in size as compared to the conventional electronic appliance. Also, where a self-oscillation drive is employed as a method to drive the

ultrasonic motor, it is possible to further reduce the size for the electronic appliance with ultrasonic motor 5.

Incidentally, if an output axis is provided to the moving member 53 to make a structure having a power transmission mechanism to transmit torque through the output axis, a drive mechanism is structured by a single ultrasonic motor.

According to this invention, because the drive signal is transmitted through the support member to the piezoelectric vibrator, there is no need to separately providing a signal transmission part. Accordingly, the expansion-and-contraction vibration and flex vibration caused on the piezoelectric vibrator is reduced in leak amount to an outside as compared to the conventional. Therefore, the ultrasonic motor according to the invention efficiently transmit a drive force caused on the piezoelectric vibrator to the moving member.

Also, the unnecessity of separately providing a signal transmission part offers size reduction for the ultrasonic motor and hence decrease in the number of manufacture processes resulting in reduction in manufacture cost.

Further, according to this invention, a function is available equivalent to that of the above invention. In addition, the piezoelectric vibrator is urged on the moving member by the elasticity of the support member. Accordingly,

the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

Further, according to this invention, the provision of the constriction in the support member reduces the vibration transmission area in the support member so that the constriction reduces the leak of vibration furthermore. Consequently, the ultrasonic motor transmits a drive force to the moving member with higher efficiency. Furthermore, the support member has elasticity due to the constriction, and has an operation equivalent to that of the above invention.

Further, acceding to this invention, because the support member is one part of the substrate, the ultrasonic motor is easy to mount on the substrate.

Further, according to this invention, a similar operation is available to that of the above invention. In addition, there is decrease in thickness of the ultrasonic motor plus the substrate. Accordingly the application of the ultrasonic motor is broadened as compared to the conventional ultrasonic motor.

Further, according to this invention, a similar operation is available to that of the above invention. In addition, because the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a similar procedure to conventional mounting of transistors or capacitors on a substrate. That is, in the ultrasonic motor of the present invention, it is possible to

simultaneously mount a motor and circuits on a substrate by using an existing electric circuit production line. Accordingly, the ultrasonic motor is reduced in mounting cost and stabilized in mounting process.

Further, according to this invention, because the support member is provided with at least part of a drive circuit, there is reduction of variation in ultrasonic motor performance resulting from mounting of the piezoelectric vibrator and the drive circuit, improving the reliability.

Further, according to this invention, because the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration, there is further decrease in externally leaking amount of vibration caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

Further, according to this invention, because the aforesaid ultrasonic motor is used in which less vibration leaks to an outside as compared to the conventional ultrasonic motor, the ultrasonic motor is increased in output. That is, the ultrasonic motor and its drive circuit are reduced in size, hence the electronic appliance with ultrasonic motor is decreased in size.